Distant Co-Design Among Professionals: A Proposal For Existing Activities Classification

Stéphanie Mailles-Viard Metz, Christophe Renaut, Jean-Laurent Cassier

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S.Metz, C. Renaut, J-L. Cassier.

ICAR Laboratory, University of Lyon, 5 av. P.M. France, 69676 Bron Cedex, France.

Abstract

This study takes into account the industrial requirements and focuses on design activities conducted through information and communication technologies. The aim of the study is to describe activities taking place during distributed, synchronous co-design, and to specify favorable conditions for the development of collaborative practices in product engineering. A previous analysis of an existing situation involving the design of an automobile enabled the construction of a semi-controlled situation, simulating the co-design of an actual product. This situation required specific knowledge in mechanics and electronics skills utilized in their respective professions.

Our observation focuses on three types of interactions in a distant distributed co-design computer-mediated task concerning specialized engineering students. The first concerns interactions between students, the second concerns student-tool interactions and the third concerns interactions between students and documents produced by the computer-mediated tools.

The situation was filmed in order to construct an analysis grid. Through video analysis, this grid enabled us to link specific activities of co-conception with its tools and products.

Recommendations for new or modified tool functions for the studied activity are made on the basis of our results, in particular for activity traces and annotations.

Keywords: Collaborative work, CSCW, design methods and tools, field study

1. Introduction

The study presented in this paper was carried out within the framework of a regional interdisciplinary research project whose principal objective has been to remotely include/understand the conduits of designers of industrial products working for the synchronous resolution of multi-industry problems. The first part of the project was focused on a study of the activities brought into play at the time of these situations. The remainder was to establish a grid of observation for real situations, to observe relations between uses and activities and to validate them in natural situations. After a brief state of the art allowing us to identify what problems exist in co-design when it is distributed, synchronous, and carried out collaboratively by different trades, we present a methodological course which enabled us to analyze the activities of the designers within a particular context of synchronous design. A qualitative analysis of the results then tracks for the proposal assumptions to validate in natural situation of work.

2. Co-design

Design in engineering is an activity distributed between the actors (in relation to several trades) and the resources (intermediate tools or instruments and objects) [1]. In our study, we are concerned with the particular case of the design when it is led in a diagram of convergent engineering [2], i.e. a co-design of products in which the actors collaborate to achieve a common goal. This co-design can be carried out under conditions from which the methods differ and can be complementary according to the stated aims: the activity is carried out in a common or distributed space, synchronously or asynchronously [3]. Within the framework of the synchronous co-design, partitioned by artifacts [4], the situation is concerned with a specific action. In addition, it is now recognized that the individuals build "common reference frames" to communicate and work together, in particular when the activities are led by different trades and in synchronous situation. The common reference frame seems to be the determining condition of the co-operation. It makes it possible to reduce the communications to what is relevant for the other operator [5] [6]. The comprehension which it makes it possible to set up is necessary for the co-operation, the negotiation and the collective decision-making [7].

3. To observe the synchronous Co-design

The analysis thus relates to the identification of activities specific to the task of distributed co-design, led by individuals of different trades. That relates to a precise part of the process of design, when the interaction is synchronous. Then, the objective is to bring knowledge at this time to propose functionalities of tools likely to assist the activities observed. At first exploratory study was led. The problem consisted of the design of an electromagnetic release. Three trades represented by students in engineering of different schools worked together, remotely on three sites, to propose a satisfactory solution: designers in electronics, designers in charge of mechanical calculation and designers in charge of mechanical manufacture. Tools of communication like NetMeeting, TeemSpeak, SameTime were used to make it possible to the designers to exchange information necessary to their work. These tools allow remote communication but present different functionalities: variation of the modes of communication (audio, video), more or less interactive division of application. This first experiment made it possible to highlight the technical difficulties of the setting in situation like the difficulty of appropriation of the tools by the subjects [8]. Following this first experiment, according to the former work undertaken on this type of situation in cognitive ergonomics [9] but also with the oversight of experts in each trade (professor-engineers of the sites observed) [10], our initial objective is to propose a grid of observation. Indeed, the idea to define a precise grid of the activities brought into play in this situation will enable us in the near term to better know the situation, to compare the use of different technological environments, and to connect sequences of activities with the use of particular functionalities. The study presented here is thus a first phase of description of a situation with expectations concerning the activities brought into play at the time of the co-design of products with the use of particular modes of communication according to roles of the designers (trades, project leaders...). The following activities represent those which we expect to observe in a situation of synchronous and remote co-design of industrial product:

Cognitive synchronization: acquisition of knowledge in the field of the other trades taking part in the process of design [11], thanks to the development of a common operative reference frame [12].

Proposals: tender of a requirement, a solution with an examination, and deliberation on behalf of the other trades.

Search for resources: document retrieval, requests between the trades, search for external expertise.

Evaluation: to determine the relevance of the solutions and the requirements suggested compared to one or more criteria (the criteria are defined by the expertise).

Project management: planning, animation, organization of the design.

Coordination: division and maintenance of the representations, requests or contribution of assistance in order to improve the co-operation, provision of its expertise, follow-up and control of the procedures in progress.

Relational: exchanges without bond with the work of design, emotional dimension...

According to the general question, we wish to validate this proposal of grid of observation, to determine how the activities of the designers are distributed, which are the relations existing between the tools and the undertaken activity and those between the produced designers and documents.

4. Study

4.1. Context

The observation is in a teaching context aimed at developing a professional know-how in students in engineering. The engineers taking part must cooperate within the framework of a project of design of an industrial product pursued by geographically distributed actors and working with various tools of communication via Internet.

4.2. Subjects

The subjects are 9 in number, and are in their third year of engineering in different fields. There are three groups : Meca 1, Meca 2, and Elec. The head of the project takes part in Meca 2.

4.3. Procedure

The experiment proceeds in three phases. The first consists of the follow-up by the students in engineering of two sessions of formations relating to the techniques and tools of communication which one can use to carry out the tasks of remote design. During the second phase, the pupils must implement the tools and the working methods for the realization of a multi-field project. The last phase includes/understands three meetings: (1) the pupils must carry out a functional analysis based on a schedule of conditions, (2) the pupils must share their technical data of dimensioning with different models (3d for the mechanics, calculation for the electronics specialists), (3) the pupils must optimize the conflicting parameters in a first phase then to take retreat on carried out work. In our study, and to validate the grid, we analyzed an extract of 10 minutes from the second meeting. During this extract, the pupil-designers collaborate to share their respective requirements concerning the structure for the mechanics and the magnetic forces for the electronics specialists. The question under consideration is to find the structure and dimensions of a circuit breaker.

5. Method Analysis

The activity of the groups of designers was recorded on a video and audio support. At the time of the phases of synchronous work known as "remotely", an overall picture made it possible to capture the environments of work of each team: possible documents used, various tools for pointing (mouse, stylus) and even the designers themselves. A view was also centered on the data-processing applications used at the time of the design. The synchronization of these various angles of sight enabled us to obtain a vision of the general activity of the designers and course of the actions and dialogues (see Fig. 1).

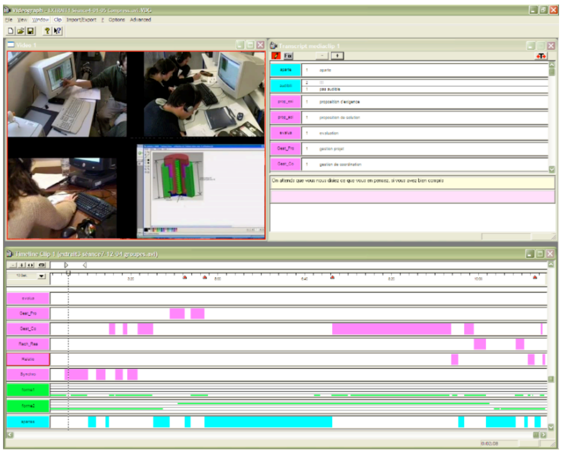

Fig. 1: Synchronization video and audio of the various sites/seen under the Vidéograph software

Videograph [13] (see Fig. 1) is a tool for classification and of analysis of audio-visual data that simultaneously makes it possible to read a video digitized and to carry out a coding and a transcription of its contents. The phase of coding requires an installation with the precondition of a whole of categories of variables representing the elements to be observed in the video. It is then a question of following a method of coding to make it possible to obtain a categorization of the contents of the video which is coherent. Each category is represented in the shape of a temporal line, called a databar, which follows the course of the video and which can either be coded, or not, as a function of time. One obtains a temporal chart of the contents of the video which can give place to statistical analyses of the coded data. Integration of the grid in Videograph: each activity of the grid of established observation is integrated like a variable. We obtain a list of databars thus corresponding to the list of our activities identified in the grid. Each one of these categories, or variable, takes as value the name of the various groups of designers (Meca 1, Meca 2, Elec , Project Leader). We can thus see quickly which designer carries out which activity. In the same way we also created new authorities of our categories for each mode of interactive mediation being likely to support it. There is thus a category ' Synchronization Cognitive Audio' and a category ' Synchronization Cognitive Writing. In the same way authorities of the category ' forms annotation' or categories ' documents' will be added for each author or manipulator.

Method of coding: We then defined intervals of coding 'referents', thus delimiting the layout on which must be made the marking of the activity, these intervals referents corresponding to the moments of synchronous work between the designers. It should be noted that the verbal exchanges are not the only mode of interaction; the moments of graphic interaction are also regarded as moments of synchronous work. The moments of asynchronous work are known as moments of ' non-exchange'. Once the grid integrated in Videograph and the intervals determined as referents several people, known as judges, carry out the coding of the same extract. If coding seems to be similar, it indicates that the grid of observation represents a good tool for categorization of the contents of the studied situation. However, it is necessary to assure the precondition that the judges have sufficient knowledge of the context of the situation observed and that they have been informed the definitions of the activities of the grid of observation. The present study, being exploratory and having been used to work out the grid of observation, we carried out coding by confronting the point of view of three judges progressively with the first coding. Each new activity to be marked was the subject of new discussions and new evolutions of the grid. The first coding is thus a coding consensus which was used to work out the grid of observation. Expert designers from engineering schools then took part in the analysis of the extract and could bring the precise details necessary to include/understand the context and the activities and thus to contribute to the evolution of the grid. The second coding was carried out once the built grid and it is on that that our results are established.

6. Results

The indicators of the activity were observed in the produced entries of tasks and the instrumented interactions recorded by the device (see Table 1).

6.1. General Results

The total analysis of the video extract shows that each activity recommended by the grid is exercised at one moment or another by the designers (see Table 2). On the other hand, the distribution of the activities is not in adequacy with our expectations: the activity of proposal for a solution is in a majority (40.6%). The designers must, during this phase of synchronous work, share their technical data of dimensioning based on different trade models. One could thus expect to have a proportion of important cognitive synchronization. Instead, the designers discuss how the structure is made, encountering difficulties focusing themselves on dimensions and of sharing the solutions and the requirements of the object to be conceived.

The interactions assumes 24% from the questions, 17% for the argumentation, 18% for the explanations and 34% are enonciations. They are very mainly led thanks to the audio mode suggested by the tools (84%). Only the stating is supported by the graphic format and text (white table and annotations), and for less than 20% of the totality of this type of interaction.

Table 1
Indicators of the activities of co-design for the studied situation:

Activity	Indicators
Cognitive synchronization	definition of concepts to ensure itself of the division of knowledge, divides of a common representation of the solutions, recall of the objectives of the meeting, divides of a common representation of the requirements, shares identical representation of the rules of the methods and strategies of design
Management of coordination and communication	Checking that each one opened the same application in a space to one moment T, that each one has the same document and took note of information in a private and shared environment, audio stock management, video stock management regulation of the exchanges. Management, distribution of the turns of word...
Project management	To manage, plan the project of design until its term. Organization of the tasks, and distribution according to competences' of the designers.
Evaluation	Agree/disagree a solution/a requirement
Proposal for solutions	Formulation of a solution, solution ever emitted, replaces one of the solutions, to state complementary ideas to support a solution...
Proposal for requirements	Formulation of the requirements: the designers add constraints in more or express their needs...
Search for resources	Seek of a document (Claroline, Google, by a request...), to seek an expertise trade, of a working group, asks of external expertise (ex: teacher, customer).

Table 2
Total distribution of the activity (%)

Activity	%
Cognitive synchronization	5
Management of coordination and communication	9
Project management	1
Evaluation	13
Proposal for solutions	40
Proposal for requirements	23
Search for resources	9

6.2. *Activities undertaken by the designers*

The first analyses clearly reflect the existence of a skew on the level of the organization of the roles in this experimentation. Indeed, the interventions of the team 'Meca 2' are almost non-existent: the project leader, which integrates the team ' Meca 2', monopolizes the microphone. It is on the level of the activity of proposal for a requirement that the group 'Elec' is expressed more; the group 'Meca 1' as for him leads activities of evaluation mainly (see Fig. 2).

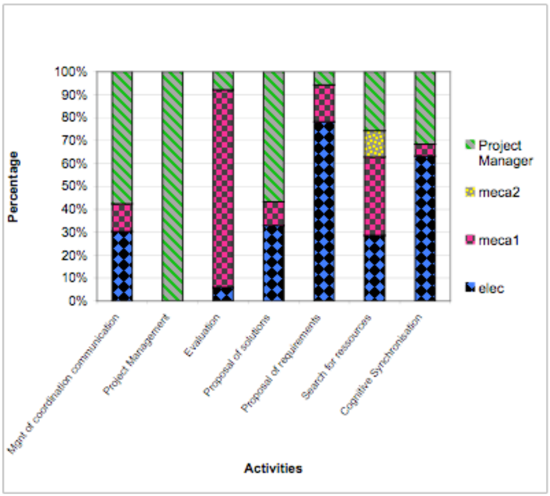

Fig. 2 : Distribution of the activities by designers (%)

6.3. *Interactions between designers and documents produced by the computer-mediated tools*

For the majority of time (93%), it is a three-dimensional chart document (representing the object to be conceived) (see Fig. 1) proposed by the group 'Meca 2' which is divided. For 5% of the time, another graphic diagram suggested by the same group is used. Lastly, the group 'Meca 1' division a model 3d for 1% of time, is very little.

7. Discussion

The results show us that our expectations in terms of activities of co-design are confirmed: each activity is observed in the selected extract. Moreover, one can expect variations of the distribution of these activities according to the situation of design, which could help with the proposal for a recommendation in terms of tools. Despite all of this, our study presents the obvious limits of the experimentation of designers-beginners. The designers, still being pupils, show that their knowledge is insufficient to propose a satisfactory solution. Moreover, they do not have the control of the data-processing tools which are proposed to them and encounter difficulties to communicate to the writing or with diagrams, or to forward documents. The activity inevitably depends on the control of the tool and the experiment. One might suspect that the activities led by the expert designers would have been distributed differently for the resolution of an equivalent problem. In addition, from a methodological point of view, it is difficult to determine if a posted document is used by the designers. Three-dimensional views of an artifact can be shared without being the subject of exchanges. We thus had to interpret in certain cases the use or not of a tool. Lastly, the inter-trade is mixed with dynamics with the group which is built. It is difficult to know if the project leader would have led the same activities if it had not been integrated into a trade group. In parallel, this situation played in discredit of the team-members of the project leader.

8. Conclusion

This study intended to validate a grid of observation for the analysis of situations of synchronous and remote co-design. The next stage of our project consists of filming a natural situation with experienced designers. The analysis of this situation will answer questions which emerged from our preliminary study: can one identify a difference between the distribution of the activities led by the experts compared to those of the students in engineering? Are there sequences of activities which one can isolate, and how can one back these activities by specific tools?

Acknowledgements

This work has been performed in the COSMOCE framework, funded by the “Region Rhône Alpes”. Partners of this project are the laboratories: 3S, GILCO, LEG (Grenoble), LIRIS, ICAR (Lyon), RIM (St Etienne) and the company: RVI SA (Lyon). We wish to thank Liliane Shoot for her help in this study.

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